

DOCUMENT RESUME

ED 403 055

PS 024 970

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TITLE Quality Science Investigation in the Early Years.
PUB DATE 96
NOTE 12p.; In: "Childhood Education: International Perspectives," see PS 024 960.
PUB TYPE Information Analyses (070) -- Reports - Descriptive (141)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Active Learning; Constructivism (Learning); Discovery Learning; Early Childhood Education; *Educational Quality; Foreign Countries; Learning Activities; *Science Activities; Science Process Skills; Skill Development; Total Quality Management
IDENTIFIERS United Kingdom

ABSTRACT

Children develop investigative skills, a spirit of inquiry, and an understanding of science within an educational context of first-hand experience and purposeful play. This article explores the issue of quality in science instruction for young children, placing it within the larger framework of quality in early childhood education. The article begins with a look at the business principles of total quality management (TQM), asserting that they have relevance for primary education, particularly when teachers are viewed as managers. It next moves into a generalized discussion of good educational practice promoting active learning, before exploring the key features of an effective quality assurance system and teachers' role in its promotion of active learning. The article next describes and evaluates a grade-one science investigation, which involved children's observation and speculation on various characteristics of kiwis and noodles. The constructivist view of learning is then evaluated as it relates to quality science instruction. The article concludes with a brief description of Britain's 1993-94 OFSTED (Office for Standards in Education) findings on the state of science instruction in primary schools. Contains 22 references. (EV)

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QUALITY SCIENCE INVESTIGATION IN THE EARLY YEARS

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This paper addresses the issue of what constitutes quality science investiga-
tion through the perspective of a small scale action research involving year
one (5-6 year old) children. For too long quality has been in the eye of the
beholder and it is time for the professionals to come to a shared perspective
and commitment to clarify what quality means in terms of teaching
processes and observable learning outcomes. West-Burnham's (1992) eight
point synthesis offers a useful framework to develop in the context of one's
own establishment.

1. Quality is defined by the customer, not the supplier.
2. Quality consists of meeting stated needs, requirements and standards.
3. Quality is achieved through continuous improvement, by prevention, not
detection.
4. Quality is driven by senior management but it is an equal responsibility of
all those involved in any process
5. Quality is measured by statistical methods - the 'cost of quality' is the cost
of non-conformity. Communicate with facts.
6. Quality has to pervade human relationships in the work place; teams are
the most powerful agent for managing quality.

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7. Quality can be achieved only by a valued work force; education, training and personal growth are essential to this.
8. Quality has to be the criterion for reviewing every decision, every action and every process.

(West-Burnham, 1992)

While many teachers may feel uneasy with the terminology of models and managerialism borrowed from industry, it has been established that all teachers are in fact managers (Lofthouse, 1994; Day et al, 1993; Bennett et al, 1984; Ball, 1987). A closer study of the total quality management (TQM) domain (the client-centred approach), points very much nearer to the child-centred philosophy of primary education. But in order to understand your clients or customers or children/pupils, West-Burnham (1992) asserts that you need information about their values, attitudes, educational level, expectations, preferences, social situation and commitment. For these reasons alone, the meaning of quality needs to be defined, refined and focused in terms of children needs, wants and aspirations. Central to this debate about quality and TQM is the role played by the senior managers. 'In order to achieve quality in learning, there has to be quality in management' (Lofthouse, 1994).

So what is quality Science? This can only be answered if we can draw parallels to what constitutes good primary practice. 'First hand experience and exploration of objects is the main aim of teaching Science to the infants' (Harlen, 1985). Through first hand experience and purposeful play, children are motivated to learn, develop a sense of enquiry and they start to develop and consolidate skills and concepts. They learn to communicate and cooperate and begin to learn to differentiate between fact and fiction.

It is in this context of explorations and investigations, set within everyday experience of children, that we enable children to develop investigative skills and understanding of Science. However, the 'immediacy and relevance of spontaneously generated activities' should not be ruled out (National Curriculum Council, 1990). What is important in developing Scientific awareness is the - search for truth - the sense of wonder at the world - the sense of identity with the world' (Bronowski, 1959). 'This search for truth is innate in us all, young as well as old' (Richards, 1982).

Through investigations and experimentation children are making sense of the world through direct experience and they are 'refining, reinforcing and readjusting their own perceptions' (The Curriculum 3-5, Warwickshire County Council, 1989). So how can we foster the development of a lively and inquiring interest in Science and how will this be related to the everyday world around the child? Areas of experience which enable the child to explore actively, to observe closely and to utilise the appropriate language register make for a good quality start. Equally important is the role of teacher's use of language (Bennett and Kell, 1989) and what constitutes quality learning activities (Balageur et.al., 1992). Greater emphasis is needed

in encouraging children to question, argue, make decisions, find solutions and communicating about events. Science allows ample opportunities for children to extend their power of discovery and seeking for relationships and applications as they explore their imaginative and real environment.

Finding evidence for what constitutes effective learning in young children is difficult (Rodger, 1994). We know something about the development of thought through the work of Piaget and others but it is important that effective learning and assessment are well grounded in systematic observation (Harlen, 1995; Alexander et.al., 1992). Care is needed to prevent the trap of 'missing completely what it is that children are learning because we are so entranced with what we want them to learn' (Drummond, 1990). In order to measure the quality of learning in the early years, educators must monitor the quality of learning experiences by noting: 'what are the children doing?; what are the adults doing?; what does the learning environment look like? and how do plans and policies support early education?' (adapted from Northern Group of Advisers, 1992). I would argue that models of effective management (plan, act, review) need to be in place so that it ensures quality learning goes on. In industrial and commercial management practice this tension is being increasingly recognised and is exemplified in the move from quality control to quality assurance (West-Burnham, 1994).

The fundamentals of quality assurance are meeting specifications through a system designed to ensure prevention. The underlying principle is one of conformance to specification and management systems should be established which allow this. 'Quality assurance is a management system designed to control activities at all stages - to prevent quality problems and ensure only conforming products reach the customer. The key features of an effective quality assurance system are:

- a) an effective quality management system;
- b) periodic audit of the operation of the system;
- c) periodic review of the system to ensure it meets changing requirements' (Munro-Faure and Munro-Faure, 1992).

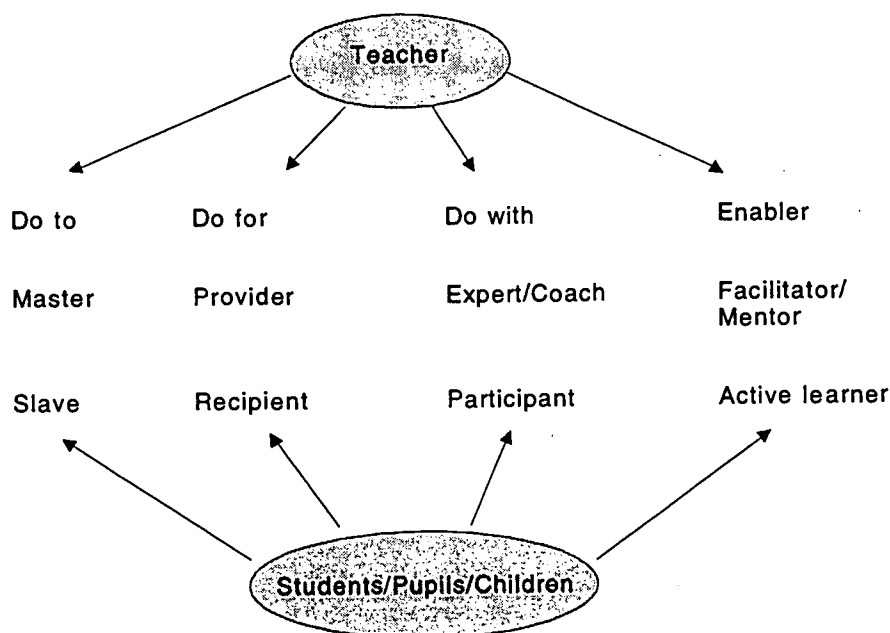
The role of the teacher is important in knowing what kind of intervention, how often and how sensitively it is appropriate to move the learning on. 'Simply providing sand, climbing frame and a butterfly garden does not mean that children will learn about maths, movement or natural science - the important thing for teachers to remember is, how will the provision be used to serve the child and how the teacher to bring the child further' (Bruce, 1987). As teachers and classroom assistants, we need to continuously evaluate the learning opportunities offered to children so that effective, quality teaching and learning becomes everyone's business.

Teachers are currently facing increasing pressures from different sectors of the community regarding what they teach and how they teach. 'A critical gaze is now being cast by politicians and parents on how teachers relate to their pupils, in terms of both teaching styles and learning outcomes (Loft-

house, 1994). It would be an interesting exercise to debate about, based on the model shown on the next page, regarding the role of the teacher within an individual school/kindergarten or nursery.

Figure 1. The role of the teacher.

(adapted from West-Burnham, 1992)



However, in the context of this paper, it is significant that a teacher acting as enabler, facilitator and mentor creates the conditions for active learning. This 'doing' and being actively involved are the very foundations of good practice for teaching young children.

A small scale research I recently undertook, assisted by a third year B.Ed. student on her school experience gave a useful insight into quality teaching and learning within the context of a good Science investigation with year one (5-6 year old) children. The account of the findings are reproduced here. She managed the assessment opportunity by being analytical, systematic, objective and focused in her observation. Evidence gained by this method allowed for mapping the conceptual development, skill level, knowledge and attitude of the small sample group.

Year one scientific investigation of Food

The emphasis of both activities was the process of close observation at a basic level, which allowed each child to spend time studying each of the food items.

The observation of the kiwis and lychees encouraged the children to use descriptive words to explain the colour, texture and the composition of the fruits. This could then be reinforced with close observational drawings.

Similarly, the noodle activity involved observation of the food, but there was a closer emphasis upon the difference between uncooked and cooked noodles, and the predictions of the cooking process.

The activities were carried out in groups of approximately six children, under the supervision and direction of an adult. On both occasions, the children were seated at a table and were presented with the food. They were able to touch and observe each item and transmit any part of their observation to the group and/or to the teacher. Individuals were encouraged to extend their observations and thinking by questioning and by further study of the dissected fruit and the noodles.

The objectives of the activities were as follows:

- 1(a) For children to closely observe the appearance of the kiwi and lychee fruit, describing the recognisable components of each.*
- 1(b) For children to pose and respond to questions concerning the appearance of the fruit.*
- 2(a) For children to closely observe the appearance of uncooked and cooked noodles.*
- 2(b) For children to describe the difference between uncooked and cooked noodles.*
- 2(c) For children to predict the change which occurs when noodles are placed in boiling water.*

Some of the questions posed were:

- Child: What's inside? (the kiwi)*
Adult: Let's cut it open and find out.
Child: Can you eat these? (the seeds of the kiwi and lychee).
Adult: You can eat the kiwi seeds but not the lychee stone.
Child: What do we have to do to cook the noodles?
Adult: We have to pour boiling water over them, so we must be very careful. What do you think will happen to them if they are put in water?
Child: They'll go soft.

Assessment of the observation of the noodle activity

The focus of the assessment was to discover whether the children could identify the noodles and /or use appropriate language to describe the appearance of the uncooked and cooked food, individually and comparatively.

For the purpose of assessment the responses of four children were focused upon.

Language Chart

	<u>Uncooked noodles</u>	<u>Cooked noodles</u>
Child A	'like spaghetti'	'thin and round'
Child B	'hard'	'soft'
Child C	'it's curly and straight'	'they come apart'
Child D	'they come apart'	'they're soft'

The children were asked to predict the change of the noodles once they had been added to hot water. Their predictions were recorded:

Child A: 'It will stay hard'.

Child B: 'They'll go soft - fall off'.

Child C: 'They'll be squashy'.

Child D: 'They'll be soft'.

Evaluation

The children were eager to observe the noodles and describe their appearance. For example, child A was keen to talk about the noodles and used the opportunity to smell, feel and observe them. Where as child B showed some hesitation in exploring the characteristics of the noodles but offered a short description after her peers' replies.

Record sheet

In order to carry out a scientific investigation, a child may employ one or more of the following skills. L1 means Level 1 (the least competence level) as applied to the Level descriptors for National Curriculum Science.

The noodle activity - summary of level attained

SKILLS	ABILITY LEVEL OF CHILD		
	Towards	L1	L2
Hypothesising	-	-	-
Observing	B	A, C, D	-
Predicting	A, C	B, D	-
Designing and Investigation	-	-	-
Executing and Investigation	-	-	-
Concluding	A, B	C, D	-
Communicating	-	-	-
KEY	A - John B - Stefan C - Lucy D - Vikki - not achieved		

From these records, individual action plan can be drawn up for each individual child and appropriate learning opportunities provided to consolidate or extend the next attainment objectives. For instance, to provide the context for further exploration of materials which change in certain circumstances: for example, dry and damp sand, uncooked and cooked eggs, or uncooked and cooked dough. Encouragement of the use of scientific language would be possible and appropriate, for children to describe different processes and stages. Another approach is to change a variable in one of the chosen processes and discuss any effect upon the end product.

Closer analysis of the noodles activity demonstrated the learning that went on in terms of the areas of experiences on offer (see the chart that follows).

The noodle activity - areas of experience

KNOWLEDGE----> WHAT? ---->

Introduction of words to describe noodles and the change upon them; beginning of scientific terminology.

UNDERSTANDING ----> WHAT? ---->

The permanent change of noodles when rehydrated and heated; the need to cook noodles before eating.

ATTITUDES ----> WHAT? ---->

Ability to verbally communicate ideas to peers/adults; ability to draw and label noodles

SKILLS ---->	WHAT? ---->	<i>Observe noodles closely;</i>
	WHY? ---->	<i>To improve close observation skills.</i>
CONCEPTS ---->	WHAT? ---->	<i>Change of noodles from hard to soft when cooked.</i>

An insight into this small scale research shows the clarity of good early years approach to teaching and learning by the student teacher and a growing awareness of how to offer first hand, challenging and yet realistically sound experiences in scientific investigation.

A constructivist view of learning based on the model of providing a stimulus, encouraging involvement and debate and then reflecting on the range of experiences had, sits relatively comfortably with the Ollerenshaw et.al.'s model (1991). Their linear structure of the constructivist view of learning can be criticised for the apparent simplicity it shows regarding the complex nature of learning, context and the environment in which the learning occurs. It may be appropriate to analyse such a model so that effective teaching and learning stages can be planned. Orientation stage does arouse children's interest, but what type of stimulus would be most appropriate for an individual child or a group of children? Elicitation allows for clarifying what they think in this model, but whose views would be considered and more importantly, whose will not and why not? The next stage of development of this model indicates an intervention/restructuring phase where children are encouraged to test their ideas, extend and revise previous thinking in light of new experiences. This has implication for the teacher who lacks the confidence or sufficient scientific background to offer such challenges- a risky business indeed! Reviewing the learning that had occurred is a significant step and offers ample opportunity for the teacher to gain evidence of the learning/teaching process. 'Application' stage forms the final step of this model where 'theory' is put into 'practice'. This phase forms a difficult challenge for the child and the teacher, in that, how do you help and encourage children to relate what they have learned to their everyday lives?

It has been argued that the issue of quality science (investigation) is based on what we all understand to be quality early years education. The firm foundation for a child is rooted in offering first hand experience within a wide setting and from this, encouraging the child to attain higher levels of knowledge, understanding, skill and attitude. To put this empirical research into context, a brief overview of early years Science provision in UK schools is provided with hints on implications for progress and development.

In many of the UK primary/junior schools there is an awareness of the need to give science a higher curriculum priority. According to OFSTED (Office For Standards in Education) inspection findings of 79 primary schools across the nation (A review of inspection findings 1993/94 -published 1995), a number of issues emerge as to the health of science provision. Great care needs to be taken to what inferences can be drawn out of context.

1. Over-prescription limits achievement.
2. Wide variations in the quality of Science assessment, recording and reporting in primary schools.
3. Standardisation of teachers' assessments are weak.
4. Lack of detailed curriculum planning for science at the whole school level- this hampers the monitoring of the experience of individual pupils.
- 5 Quality of lessons:
 - satisfactory = 79 %;
 - good-very good = 21 %
 Quality of teaching:
 - satisfactory = 73 %;
 - good-very good = 33 %
 Quality of assessment and recording:
 - better at KS1 (5-8 year olds) than KS2 (7-12 year olds)- systems in place to show link with curriculum planning, recording achievement and standardisation procedures.

Issues for consideration

- a) Enhance science subject knowledge.
- b) Appropriate strategies for assessing pupils' progress in scientific knowledge and skills- feedback and feedforward between assessment and planning.
- c) Focused investigative work.
- d) Systematic planning.
- e) Non-teaching time to monitor science teaching throughout the school.
- f) Danger of labelling, low expectation and low self-esteem.
- g) Developing an understanding of the role of other adult(s)/support by sharing the planned learning objectives.
- h) Provision for a variety of learning experiences from imaginative play to scientific exploration.

Evidence of standards achieved

'Standards of achievement- pupils work together on practical tasks with curiosity and interest; well motivated; enthusiastic participation; basic scientific vocabulary is being developed; pupils are beginning to learn how to formulate questions for investigation; make comparisons and conclusions based on evidence; poor on developing higher order skills such as those of prediction and hypothesising'.

'Quality of teaching- practical work drawing on pupils' own experiences, active involvement of pupils and promoting the skills of scientific investigation; matching appropriate tasks to ability groups; recording in a variety of ways matched to writing skills; sufficiently stretched mentally; not an over-use of worksheets or whole class instruction- leads to under-development of scientific knowledge, understanding and skills' (HMI, OFSTED, 1995).

Quality science investigation in the early years has to be planned for, delivered with imagination and in the best way that we as early years educators know to be the best practice.

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ACKNOWLEDGEMENT: LISA WERRETT, THIRD YEAR B.Ed STUDENT AT NENE COLLEGE OF HIGHER EDUCATION WHOSE RECORD OF WORK WAS USED AS PART OF THIS PAPER. LISA CARRIED OUT HER SCHOOL EXPERIENCE AT A KETTERING INFANT SCHOOL.



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